Astrophysics Projects Division

PCOS — Physics of the Cosmos Program

COR — Cosmic Origins Program

Program Annual Technology Reports (PATRs)

Technology Capability Gap Identification and Prioritization Process

PhysPAG Meeting at AAS

January 5, 2014

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Technology Development Model

- **Identify** Program technology capability gaps based on an annual prioritization of inputs submitted by the science and technology community and on the guidance of the Astrophysics Implementation Plan and current programmatic assessment.
- **Invest** in strategic technology development through merit-based review processes
  – Through competitive solicitations that are evaluated by a peer review process (competed; e.g., Strategic Astrophysics Technology (**SAT**) development) or through a merit-based process evaluated by a Technology Management Board (**TMB**) (directed; e.g., "targeted" technologies)
- **Monitor** the development and maturity of funded technologies
- **Support** mission concepts in formulation with the guidance of Technology Development Plans (TDPs)
- **Enable** future missions by supporting the infusion of maturing technologies

Astrophysics Division Technology Development Funding Sources

NASA's Astrophysics Division funds the development of technology at all levels of maturity.

- **The Astrophysics Research and Analysis (APRA) program** funds technology development in the earliest phases, from basic principles through proof-of-concept (typically Technology Readiness Level (TRL) 1 through 3). APRA also funds suborbital science and/or technology investigations that can be carried out with sounding rockets, balloons, or other platforms (CubeSat, ISS) which can be at TRLs higher than 3.
- **The Strategic Astrophysics Technology (SAT) program** matures key technologies to the point at which they can be implemented into space flight missions, taking them from proof-of-concept through a high fidelity demonstration of a design that meets specific performance requirements (mid-TRL; 3 through 6).
- The final maturation stages (TRL 6 through 9) focus on proving the technology's flight-worthiness for a specific mission. These stages are addressed by incorporating the technology into a **flight project's implementation plan.**

Note: TRL definitions are per the NPR 7123.1B, NASA Systems Engineering Processes and Requirements, effective April 13, 2013

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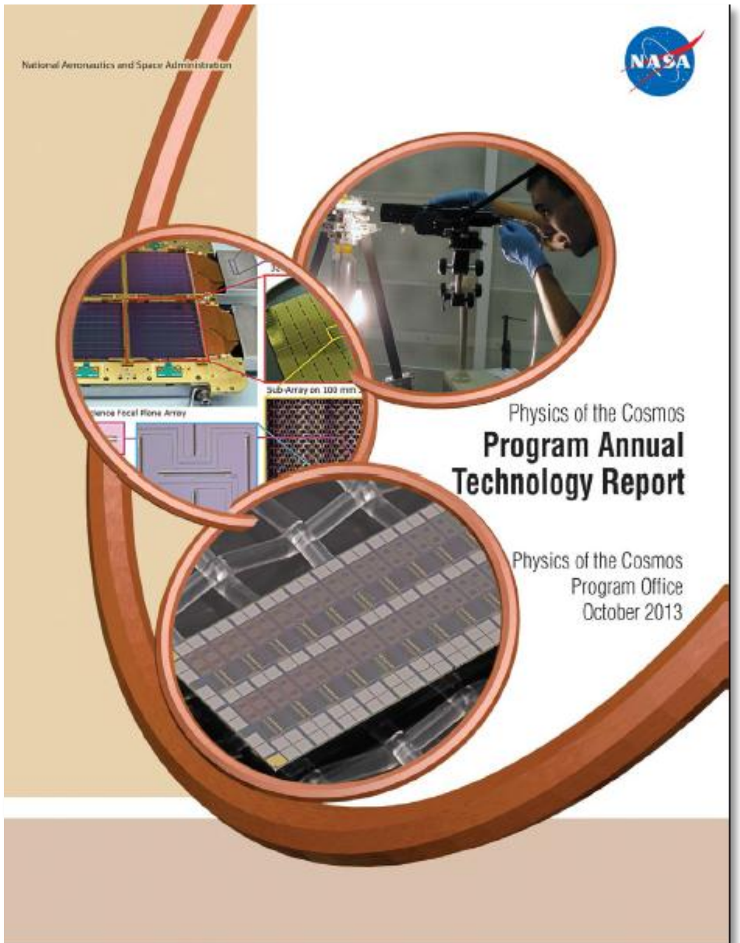
2013 PCOS
Program Annual Technology Report (PATR)



The PATR is an annual report that summarizes the Program's technology development activities for the prior year.

- Provides overview of the Program and its technology development activities
- Give status of the Program's strategic and targeted technology development for the prior year and announces the new SAT award selections.
- Summarizes the technology capability gaps obtained from the community.
- Provides a prioritized list of the capability gaps for the coming year to inform the SAT proposal calls and the selection decisions
- Updated annually and released in October to support annual technology development planning.

The PCOS PATR can be downloaded from https://pcos.gsfc.nasa.gov

Objectives and Purposes of Prioritization Process

- **Objectives**
  - Identify technology capability gaps that are applicable and relevant to the Program's objectives as described in the Astrophysics Implementation Plan
  - Rank these technology capability gaps to represent our recommended investment priorities
- **Purposes**
  - Inform the SAT solicitation and other technology development program planning (SBIR and other STMD activities)
  - Inform technology developers of the Program's capability gaps to help focus efforts
  - Guide the selection of technology awards to be aligned with Program goals and science objectives. This process supplements and does not replace the existing SAT peer review selection process
  - Improve the transparency and relevance of Program technology investments
  - Inform the community about and engage it in our technology development process
  - Leverage the technology investments of external organizations by defining capability gaps and NASA as a potential customer

Overview

- The community identifies technology capability gaps each June by working with the Program Analysis Group (PAG) or through direct individual submission to the Program Office's website.
- The Program's Technology Management Board (TMB) reviews and prioritizes the community identified technology capability gaps in July and recommends an investment consideration.
  - TMB membership includes senior members of the Astrophysics Division at NASA HQ and its Program Offices, and as required, independent subject matter expert(s) from the community.
  - Technology gaps prioritization is based on a published set of criteria that addresses scientific priorities, benefits and impacts, scope of applicability, and timeliness.
- The technology capability gaps and the resulting priorities are published each year in the PATR which is released in October.

PCOS Capability Gaps Prioritization From 2013 PATR (priorities 1 and 2)

Priority	Capability Gaps	Science
1	Large format Mercury Cadmium Telluride CMOS IR detectors, 4K x 4K pixels	Dark Energy
	Telescope design with stringent length and alignment stability with low straylight	Gravitational Wave
	Large format high-resolution X-ray microcalorimeter	**X-ray ***
	High resolution phasemeter	Gravitational Wave
	Segmented replicating mirrors	**X-ray ***
2	Frequency-stabilized metrology lasers	Gravitational Wave
	Large format arrays of CMB polarimeters with noise below the CMB photon noise and excellent control of systematics	Inflation
	Low noise and long life microthrusters	Gravitational Wave
	High throughput polarization modulating optical elements	Inflation
	Off-plane reflection gratings	**X-ray ***
	Critical angle transmission gratings	**X-ray ***

*** In support of NASA's interest in a possible collaboration with ESA's L2 mission, the PCOS SAT call has been amended to solicit only proposals for technologies for X-ray astrophysics.**

How The PhysPAG/Community Can Contribute

- Provide feedback on the technology capability gaps identification and prioritization process

- Identify, collect and consolidate strategic technology capability gaps by the end of June for prioritization and other technology planning

- Propose to the SAT – due March 21, 2014

Technology Capability Gap Submission

- A technology capability gap can be identified by anyone and provided to the PO for prioritization in either of two ways:
  - Provide it to the appropriate sub-group of the PhysPAG
  - Submit it through the PCOS Program website and it will be forwarded to the PhysPAG (http://pcos.gsfc.nasa.gov/technology)

- Although capability gaps are solicited annually and collected at the end of June to begin the prioritization process, they can be submitted to the PCOS website at any time.

Lessons Learned from Previous Technology “Needs” List

- **The previous PCOS technology needs list was unwieldy (>90 inputs) given that we can only afford to invest in very few SATs**

- **The list included some needs that were not applicable or relevant such as those that are:**
  - Not in the PCOS Program charter (ex. launch vehicle, rover, avionics technologies)
  - Requiring engineering solutions and not technology developments
  - So vaguely defined that it is not possible to evaluate their needs status
  - Subset or duplicate of another technology needs input
  - Already at TRL 6 or higher
  - Specific implementations, solutions or approaches
  - Have a time horizon beyond the strategic goal of the SAT program
  - Not within the scope of the Astrophysics Implementation Plan (AIP)

Suggestions for Future Technology Capability Gaps List

- **Suggestions to obtain a more effective Technology Capability Gap list for prioritization to inform the SAT program**
  - Focus on technology capability gaps associated with missions prioritized in the Astrophysics Implementation Plan and any relevant programmatic directives
  - Submit technology gaps that are directly applicable to Program objectives. Don't include gaps that are not in our charter such as technologies associated with launch vehicle, rover, avionics, spacecraft systems, etc.
  - Don't include gaps that don't require technology development, that are not well defined, that are redundant (duplicate, similar, or subsets of other needs), or are at TRL 6 or higher
  - Inputs should be submitted as technology capability gaps between the current state-of-the-art and the science objective targeted and not as specific implementations

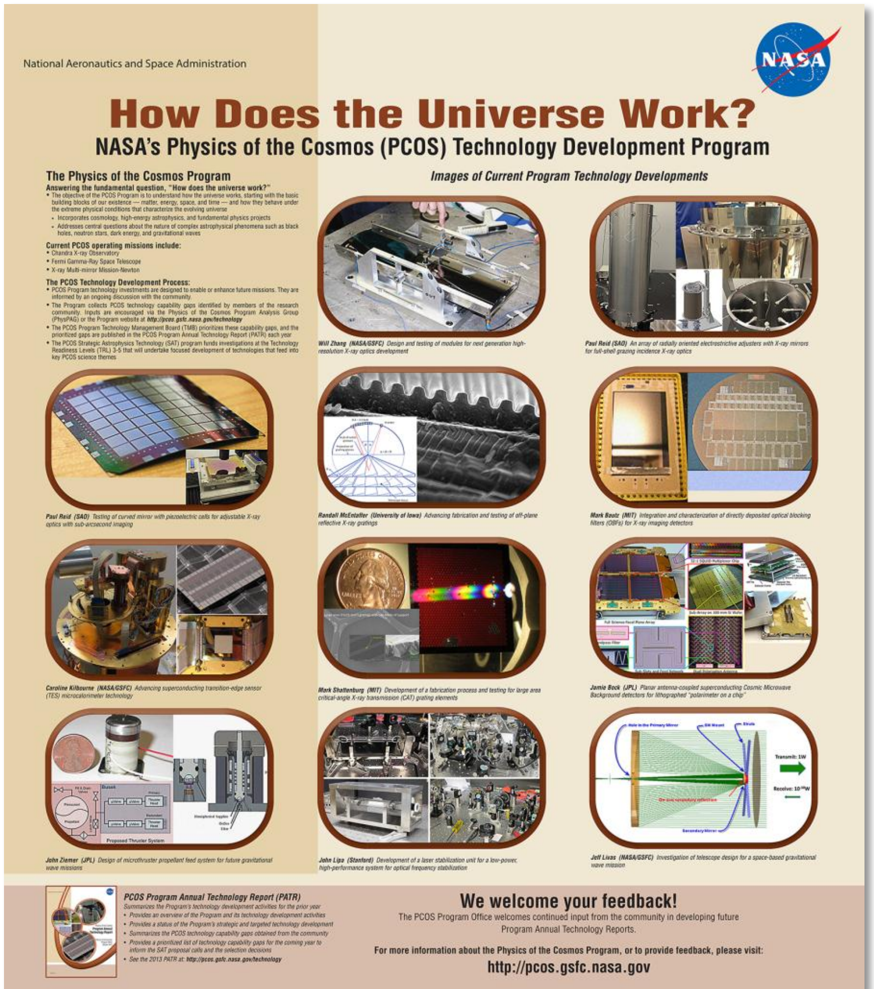
An “Ideal” Technology Capability Gaps List

- Consists only of technology capability gaps that are consistent with the PCOS program objectives as articulated by the Astrophysics Implementation Plan and any relevant current programmatic directives
- Inputs received from a broad and diverse community base
- Technology gaps that are identified as capability gaps and not specific implementation approaches
- Developed in a process that is open and impartial
- Inputs description have no perception of Program endorsement or advertising for anyone or any organization.
- List is concise, non-redundant, and well-defined
- There is no proprietary or ITAR-sensitive information

Conclusions

- A process is in place to identify and prioritize technology gaps to inform the SAT call and selection and to support other Program technology development activities
- This process improves the transparency and relevance of our technology investments and leverages the technology investments of external organizations
- Community feedback and input to the process is appreciated as we continue to evolve the process to best achieve the objectives of the PCOS Program.

SAT Sessions at the AAS



"Preparing for Future NASA Missions: The Strategic Astrophysics Technology Program"

- **Joint PCOS, COR and Exoplanet sessions**
- **Poster Session (#344)** on Wednesday from 9am – 6:30pm in the Exhibit Hall
- **Special Session (#339)** on Wednesday from 6:30 - 8:00pm in the National Harbor 2

Backup

Prioritization Criteria Address…

- **Strategic Alignment:** Given the scientific and/or programmatic priorities, as determined by the Astrophysics Implementation Plan (AIP) or current programmatic assessment, what is the importance of the capability?
- **Benefits and Impacts:** What positive impact would filling the capability gap have on the science return or the ability to implement a notional mission? To what extent does filling the capability gap enable/enhance a mission?
- **Scope of Applicability:** How many mission concepts can benefit from filling this technology capability? How crosscutting is it?
- **Time to Anticipated Need**: How much time is available before the technology capability is needed to be at TRL5/6 or before the decision to invest is necessary?

Prioritization Criteria for 2013

Technology Needs Prioritization Criteria										
					Score Meaning				
#	Criterion	Weight	Max Score	Weighted Score	General Description/Question	4	3	2	1	0
1	**Strategic Alignment**	10	4	40	Technology enables or enhances a mission concept that is prioritized by the Astrophysics Implementation Plan (AIP) (which incorporated the recommendations of the Decadal Survey within current budgetary constraints) or current programmatic assessment.	Applicable mission concept receives highest AIP ranking	Applicable mission concept receives medium AIP ranking	Applicable mission concept receives low AIP ranking	Applicable mission concept was not ranked by the AIP but was positively addressed in the 2010 Decadal Survey	Not ranked by the AIP or the 2010 Decadal Survey
2	**Benefits and Impacts**	9	4	36	Impact of the technology on a notional mission concept. Degree of unique or enabling/enhancing capability the technology provides toward the science objective and the implementation of the mission.	Critical and key enabling technology - required to meet mission concept objective(s)	Highly desirable technology - significantly enhances science objective(s) and/or reduces need for critical resources	Desirable - offers significant science or implementation benefits but not required for mission success	Minor science impact or implementation improvements	No science impact or implementation improvement
3	**Scope of Applicability**	3	4	12	How cross-cutting is the technology. How many mission concepts could benefit from this technology?	The technology applies to multiple mission concepts across multiple NASA programs and other agencies	The technology applies to multiple mission concepts across multiple NASA programs	The technology applies to multiple mission concepts within a single NASA program	The technology applies to a single mission concept	No known applicable mission concept
4	**Time To Anticipated Need**	3	4	12	When does the technology need to be ready for a decision point or implementation?	Decision point is now or overdue, and implementation is needed within 7 years (this decade)	Decision point is now or overdue, or implementation is needed in 8 to 12 years (early to mid 2020's)	Decision point is less than 5 years away, or implementation is needed in 13 to 17 years (late 2020's)	Decision point is 5 - 10 years away, or implementation is needed 18 years or later (early 2030's)	No anticipated need

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PCOS Technology Needs Prioritization From 2013 PATR (priority 3)

Very large format (>10^5 pixels) FPA with background-limited performance and multi-color capability	FarIR
Cooling to 50-300 mK	FarIR
Stable and continuous sub-Kelvin coolers for detectors	Inflation
High rate X-ray Si detector (APS).	X-ray
Large throughput, cooled mm-wave to far IR telescope operating at background limit	FarIR
Optically blind X-ray CCD detectors	X-ray
High-throughput, light, low-cost, cold, mm-wave telescope operating at low backgrounds	Inflation
high throughput anti-reflection coatings with controlled polarization properties	Inflation
Optical Bench	Gravitational Wave
Arcsecond attitude control to maintain resolution	X-ray
Molecular clocks/cavities with 10E-15 precision over orbital period; 10E-17 precision over 1-2 year experiment.	Fundamental Physics
Cooled atomic clocks with 10E-18 to 10E-19 precision over 1-2 year experiment	Fundamental Physics
Compton telescope on single platform	Gamma
Cooled Ge	Gamma
Arrays of Si, CZT or CdTe Pixels	Gamma
Active cooling of germanium detectors	Gamma
Coded aperture imaging: ~5 mm thk W and ~2.5 mm holes; ~0.5 mm W and ~0.2 mm holes	X-ray
Finely pixelated CZT detectors for hard X-rays	X-ray
ASIC on each ~20x20 mm crystal	X-ray
Gravitational Reference Sensor (GRS)	Gravitational Wave
Coupling of ultra-stable lasers with high-finesse optical cavities for increased stability	Fundamental Physics
ASIC readouts	Gamma
Long booms or formation flying	Gamma
1 m precision optics (1/1,000)	Gravitational Wave
wavefront sensing with cold atoms	Gravitational Wave
Large area atom optics	Gravitational Wave
LHP to radiators for ~-30 deg (Si) and ~-5 deg (CZT) over large areas	X-ray
Low power ASIC readouts	X-ray
Passive cooling of pixel arrays	X-ray
Source isolation by collimator	X-ray

Gigapixel X-ray active pixel sensors	X-ray
Megapixel microcalorimeter array	X-ray
Depth graded multilayer coatings for hard X-ray optics	Next
Sun-shield for atom cloud	Gravitational Wave
Low-frequency, wide-bandwidth, low-mass science antennas	20 cm
Thermal stability/control less than 10E-8 K variation	Fundamental Physics
Hard X-Ray grazing incidence optics with multi-layer coatings with at least 5" angular resolution	X-ray
Lightweight adjustable optics to achieve 0.1 arcsec high resolution grating spectrometer	X-ray
Advanced scintillators and readouts for gamma-ray detection	Gamma
Lightweight, high throughput Fresnel optics	Near UV
Scintillators, cooled Ge	Gamma
Active cooling of germanium detectors	Gamma
3 m precision optics	Gravitational Wave
Laser interferometer ~1 kWatt laser	Gravitational Wave
Gravity Reference Unit (GRU) with ~100x lower noise	Gravitational Wave
10 W near IR, narrow line	Gravitational Wave
Photocathodes, microchannel plates, crossed grid anodes	X-ray
>3 m^2 Si (or CZT or CdTe) pixel arrays or hybrid pixels -- possibly deployable	X-ray
extendable optical bench to achieve 60 m focal length	X-ray
Thin lightweight X-ray collimator	X-ray
Point source optimized X-ray concentrator	X-ray
Broadband X-ray Polarimeter	X-ray
Finely pixelated detectors for high angular resolution hard X-ray imaging.	X-ray
Ultra-low power, temperature resistant, radiation tolerant analog electronics	21 cm
Ultra-low power, temperature resistant, radiation tolerant digital electronics	21 cm
Autonomous low-power generation and storage	21 cm
focusing elements (e.g., Laue lens) on long boom or separate platform	Gamma
Lobster eye X-ray optics for all-sky monitors	X-ray
Megapixel ccd camera	Gravitational Wave